2003 AFCEE Technology Transfer Workshop
San Antonio, Texas
Promoting Readiness through Environmental Stewardship

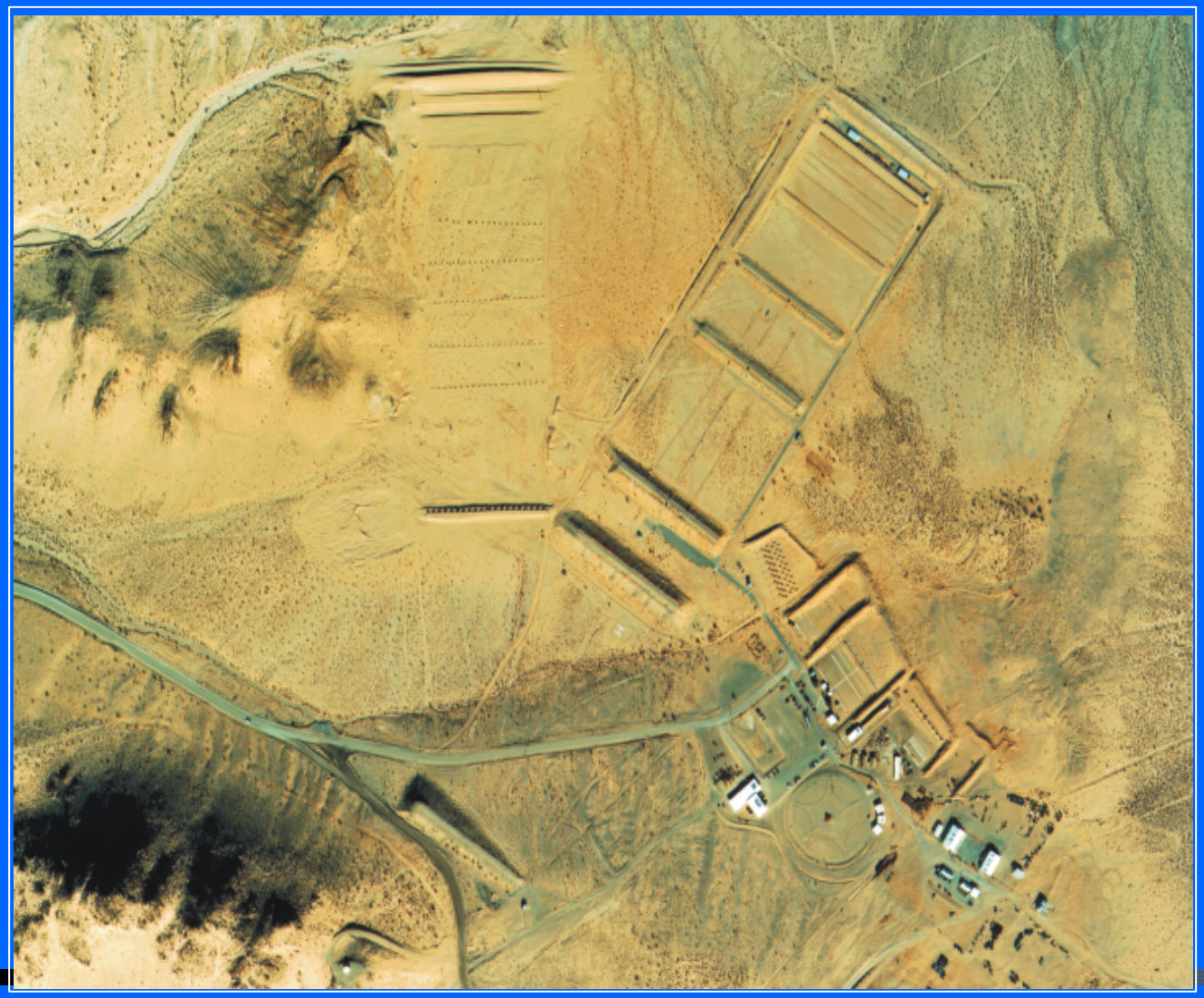
Particulate and Molecular Lead Processing Technologies at Small Arms Ranges

Arun R. Gavaskar
gavaskar@battelle.org
Battelle
27 Feb 2003

Background

- Active Military Facility Since First Army Use in 1940
- Occupied by the Marine Corps Since 1952
- Troops Are Trained and Qualified in Rifle and Pistol Use
- Training for Over 10,000 Marines Per Year
- Also Used by About 1,500 Other Shooters Each Year

Twentynine Palms Small-Arms Ranges



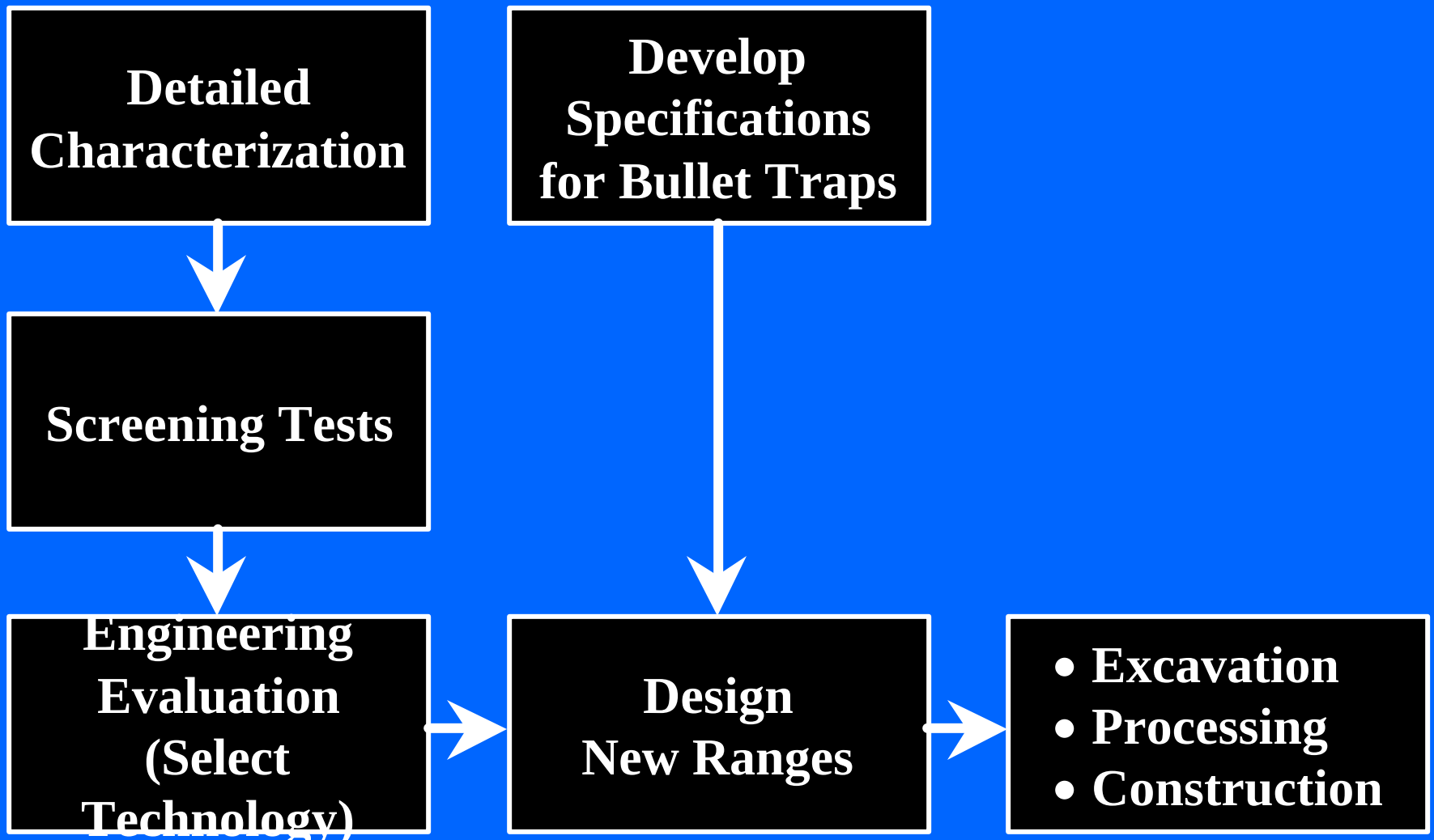
Overall Project Objective

- **Remove and Process Contaminated Soils From 3 Ranges:**
  - **Known-distance Rifle Range “Rifle Range”**
  - **Battle Sight Zero Range “BZO Range”**
  - **Known-distance Pistol Range “Pistol Range”**
- **Install Bullet Traps at Those Ranges**

Overall Project Objectives

- Characterize Ranges
- Perform Environmental Assessment
- Establish Soil Processing Goal (based on HHRA)
- Perform Treatability Study and Select Processing Technology
- Design Soil Management Pad
- Excavate and Treat Range Soil and Construct Bullet Traps

Project Approach Used at Twentynine Palms



Site Characterization and Assessment

- **Initial Assessment by NFESC in 1996 and 1997**
  - **Most lead found in berms and behind berms**

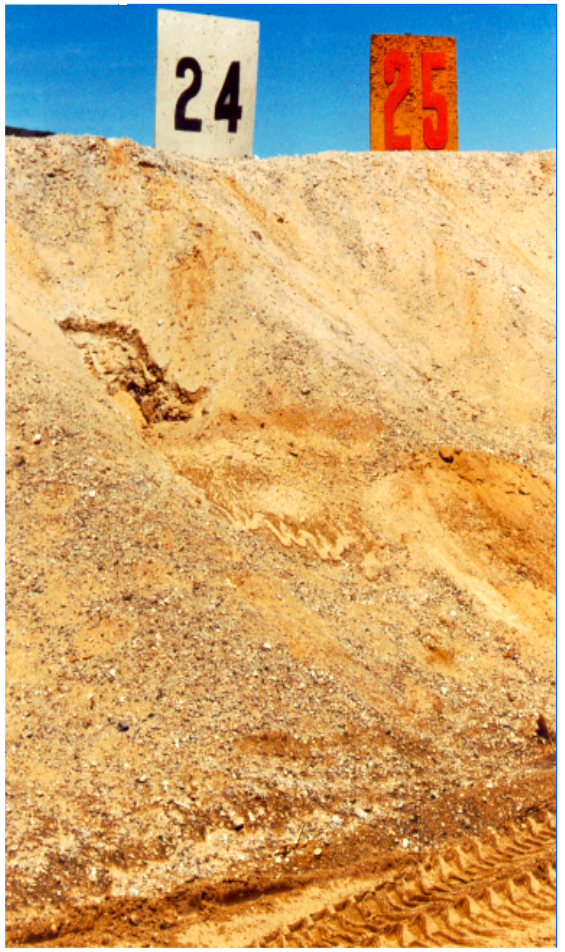
    (Values to 35,000 mg/kg falling to <1,000 mg/kg within 250 ft)
  - **Lead concentrations dropped rapidly with depth**

    (26,000 to 700 mg/kg in 2 ft)

- **Additional Characterization by Battelle in 1997**
  - **Focused on complete characterization of the berms**
  - **Included trenching into the various berms with a backhoe**
  - **Bullets found throughout the berm at rifle range**
  - **Bullets found only at surface of pistol and BZO ranges**

Site Characterization at Twentynine Palms

Site Characterization (continued...)



Environmental Assessment and Concerns

- NEPA Documentation
- Evaluated Proposal Action, Alternative Actions, and No Action Baseline
- Human Health Risk Assessment ("Lead Spread" Model)
- Ecological Risk Assessment
- Desert Tortoise (Endangered Species)
- Historic Property
- Bullet Trap Screening Study

Regulatory Considerations

- EPA Military Munitions Rule (40 CFR 260)
  - Range maintenance operations being performed at an active range
  - Soils were not considered RCRA waste, lead was recycled
- Local Regulators adopted the following position
  - Did not apply California HazWaste Regs (CCR Title 22)
  - Used Lead Risk Assessment Spreadsheet from DTSC

Bench-Scale Technology Screening Tests

- Physical separation
  - Wet screening (removes most of the lead)
  - Gravity separation
- Solidification/Stabilization
  - Cement
  - Phosphate
  - Asphalt
- Acid Leaching

Bench-Scale Testing (Treatability Studies)

Bench-Scale Testing (continued…)

Lead Concentrations in Bullet Pocket Soils after Bench-Scale Processing

Bench-Scale Processing	Lead Concentration (mg/kg) in Bullet Pocket Soils after Processing			
	Rifle Range Berm	BZO Range Berm	Pistol Range Berm	Optional Range Berm
10 Mesh Screening Only	17,627	1,436	71	231
10 Mesh Screening + Physical Separation	4,769	498	72	188

Lead Concentrations in General Berm Soils after Bench-Scale Processing

Bench-Scale Processing	Lead Concentration (mg/kg) in General Berm Soils after Processing			
	Rifle Range Berm	BZO Range Berm	Pistol Range Berm	Optional Range Berm
10 Mesh Screening Only	15,932	283	100	154
10 Mesh Screening + Physical Separation	3,597	110	44	61

Lead Concentration Data at Berm Surface

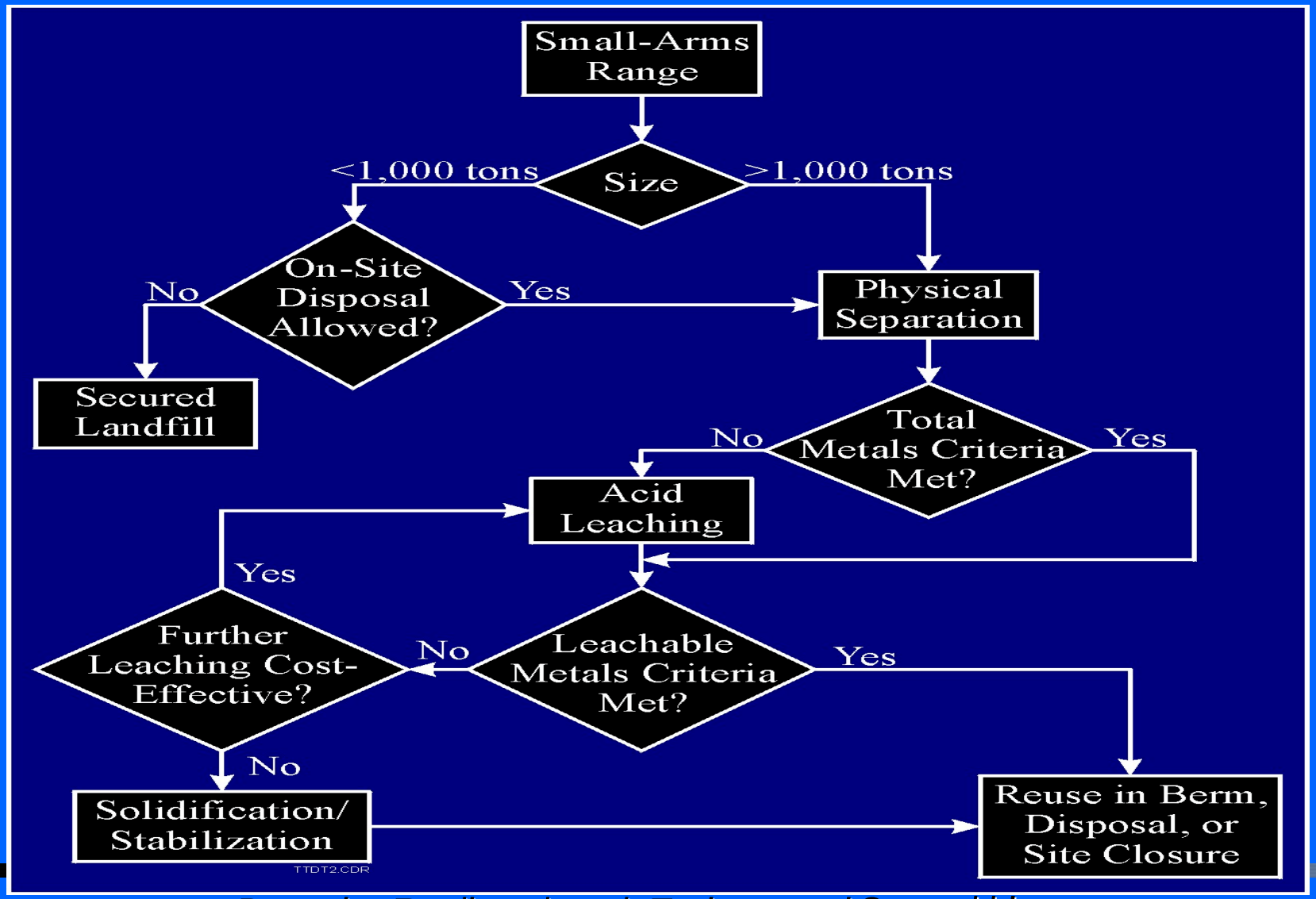
Location		Average Lead Concentration (mg/kg)	Percent Reduction (%)
Rifle Range Berm	Pre-screening	81,508	60.4
	Post-screening	32,258	
Pistol Range Berm	Pre-screening	233,142	99.1
	Post-screening	2,010	
BZO Berm	Pre-screening	27,021	81.8
	Post-screening	4,930	

Soil Management Pad Design

- Designed and Constructed to serve as:
  - Staging area for soil to be processed
  - Staging area for processed soil awaiting TCLP results
  - Staging area for lead-bearing materials awaiting recycling
  - Area for soil-processing operations
- 300 ´ 300 ft asphalt pad
- 7,800 cubic yards (11,700 tons) of contaminated soils were excavated

Site Chosen for the Soil Processing Pad

Treatment Train Decision Tree for Small-Arms Ranges



Excavation Plan

- **Rifle Range:**
  - **Remove entire rifle range berm**
  - **Remove 6 inches of soil from surface (150 feet behind berm)**
- **Pistol Range**
  - **Remove 1 foot of surface soil from berm (face, top, back)**
  - **Remove 6 inches of soil from surface (50 feet behind berm)**
- **BZO Range**
  - **Remove 1 foot of surface soil from berm (face, top, back)**
  - **Remove 6 inches of soil from surface (50 feet behind berm)**

Excavated BZO Range

Soil Processing Operations

- Mobilized in June and began shakedown testing
- Full-scale operations commenced in mid-July
- Completed processing in mid-September.

Construction of the Soil Processing Plant

Soil Processing Operations Production Results

- Average daily processing rate was 127 cy/day (190 tons/day)
- During final month, rate was 176 cy/day (265 tons/day)
- 24,700 mg/kg lead in feed soil
- 1,800 mg/kg lead in processed soil
- 230 tons of high purity lead was recovered and recycled

Bullet Trap Screening Study

- Evaluated three types of systems
  - Friction traps
  - Deceleration traps
  - Impact traps
- Evaluated using 10 performance criteria with weighting factors

Bullet Trap Infrastructure

- Constructed cement pads, drainage ditches, retention ponds
- Cement pads: 4,000 psi, 8” thick in front, 12” thick in back
- Installed permanent electrical power (480 V, 3-Phase) for Dust Collection Units (DCUs)

Bullet Trap Installation Requirements

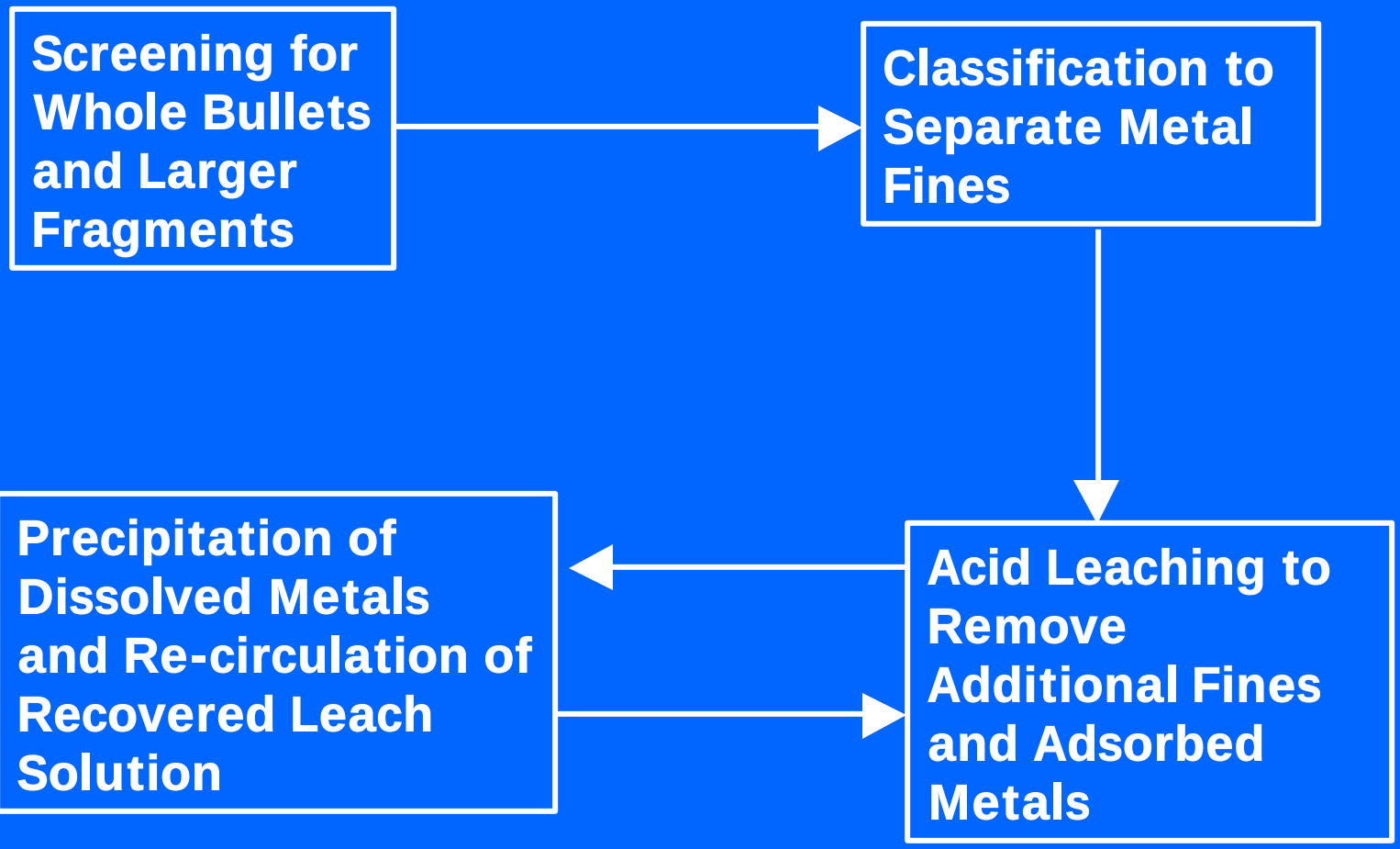
- Designed for wind load of 100 mph and live load of 20 lb/ft^2
- 3/8” sheet steel panel
- Tied to deceleration chamber
- Lead collected in 5 gal buckets
- DCU’s tied to deceleration chamber

Bullet Trap Construction

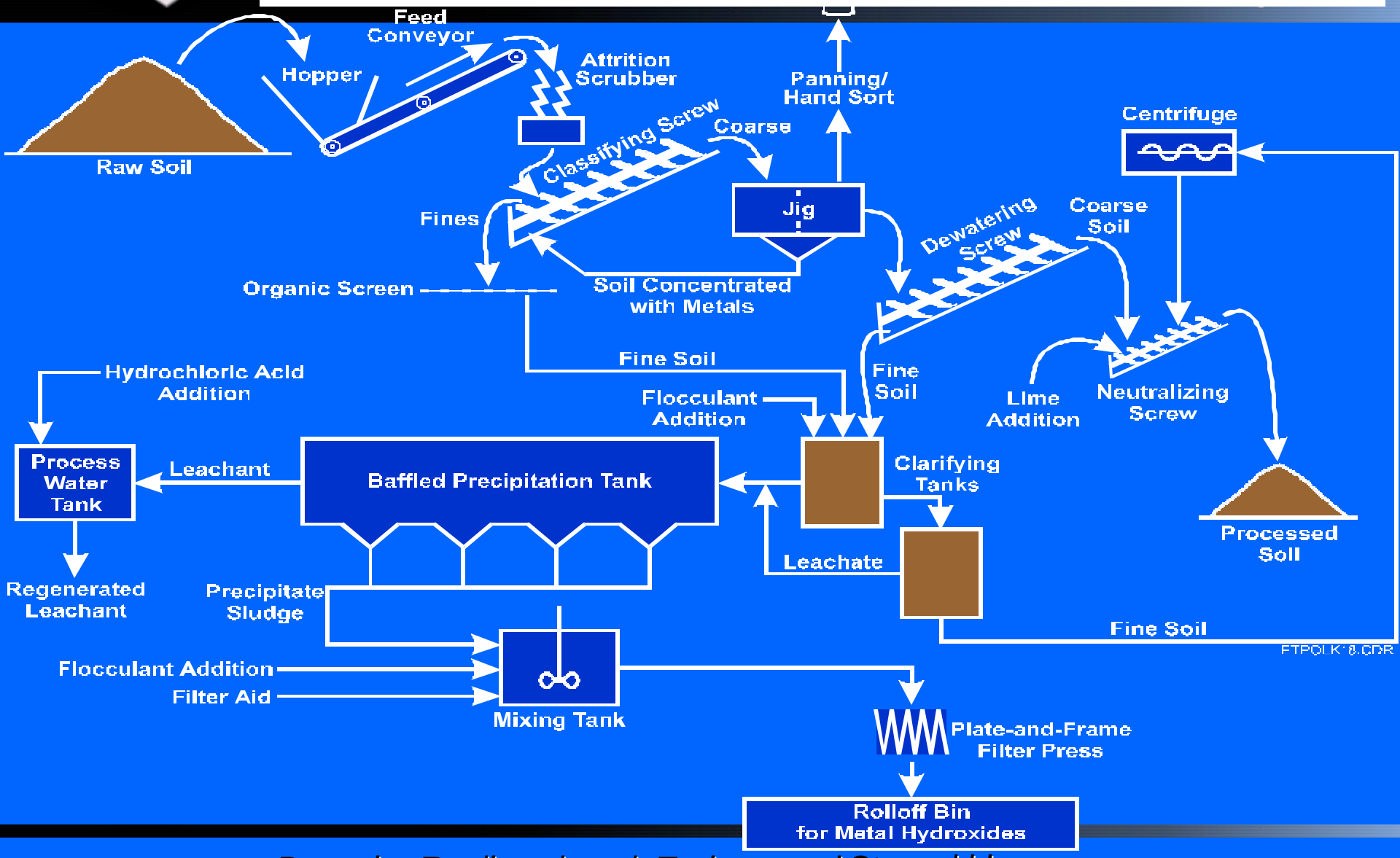
Results and Future Work

- Bench-Scale Results Were Used for Selecting the Technology Used
- Full-scale Processing Operations Recovered Lead and Reused the Site Soils
- Bullet Traps Installed and Have Been in Operation for Over 1 Year; Currently Being Studied to Determine O&M Costs

Fort Polk – Physical Separation and Leaching Principles

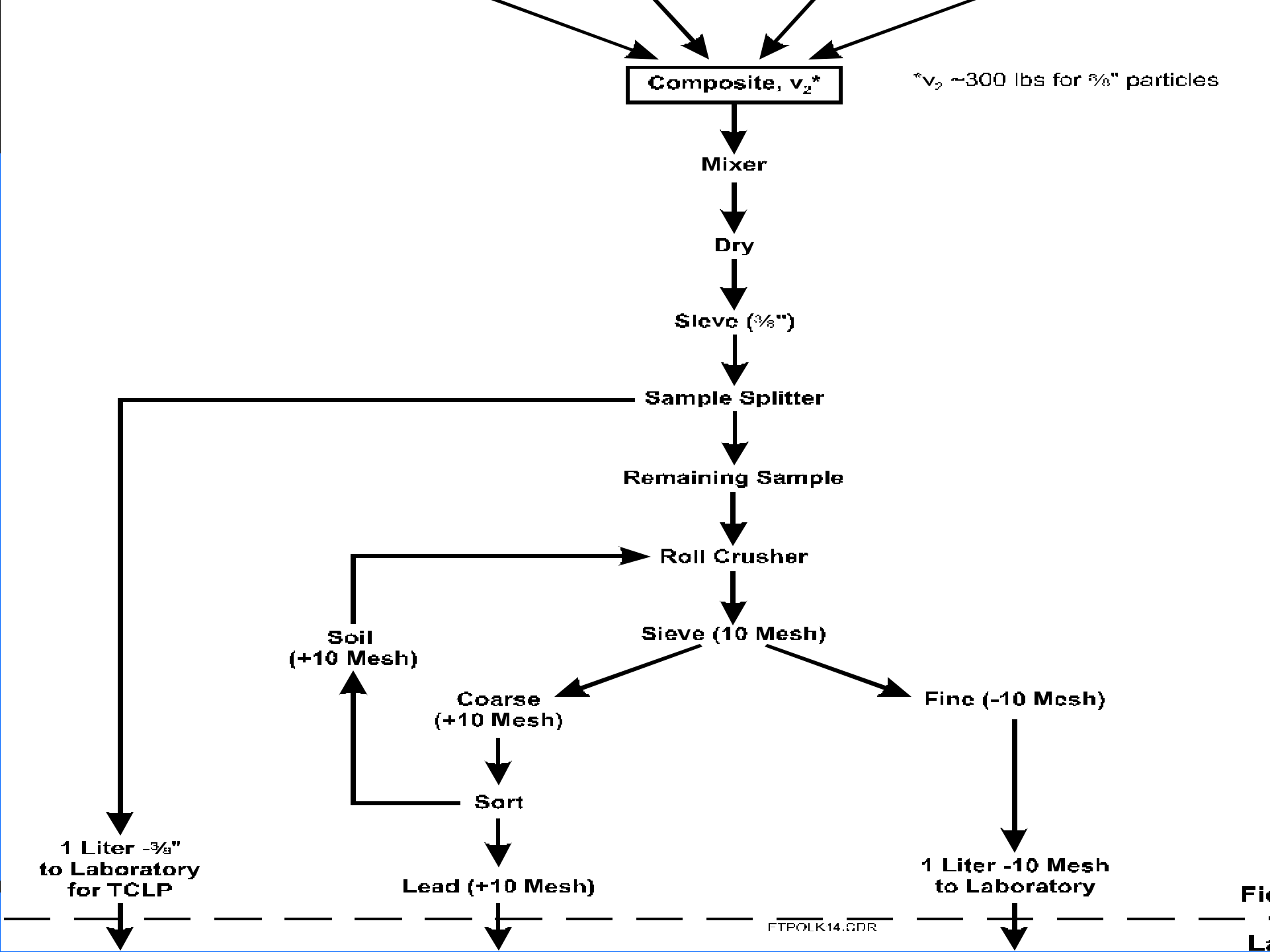


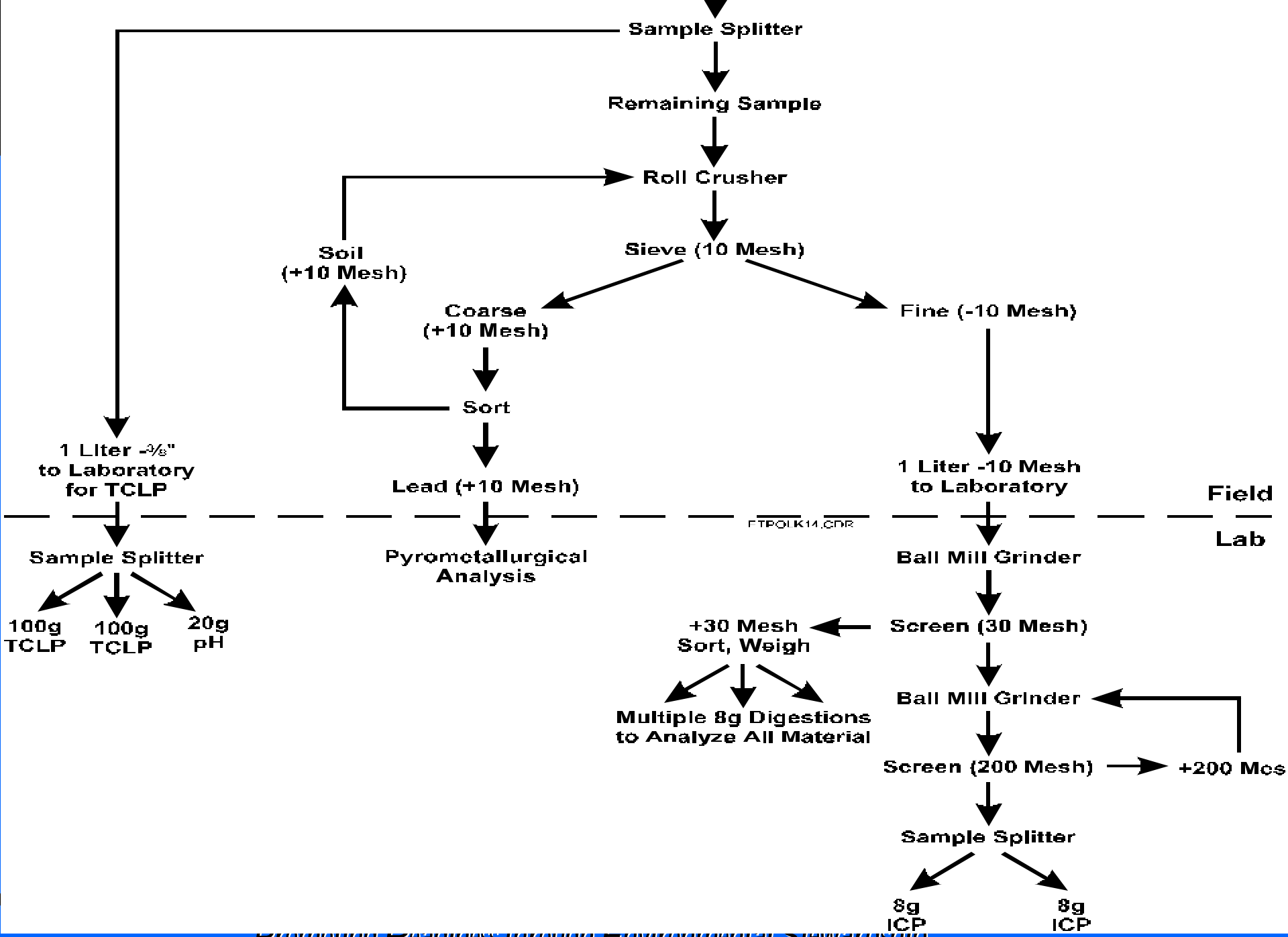
Physical Separation and Hydrochloric Acid Leaching



Vendor 1's Plant
- Physical Separation and Acetic Acid Leaching Process

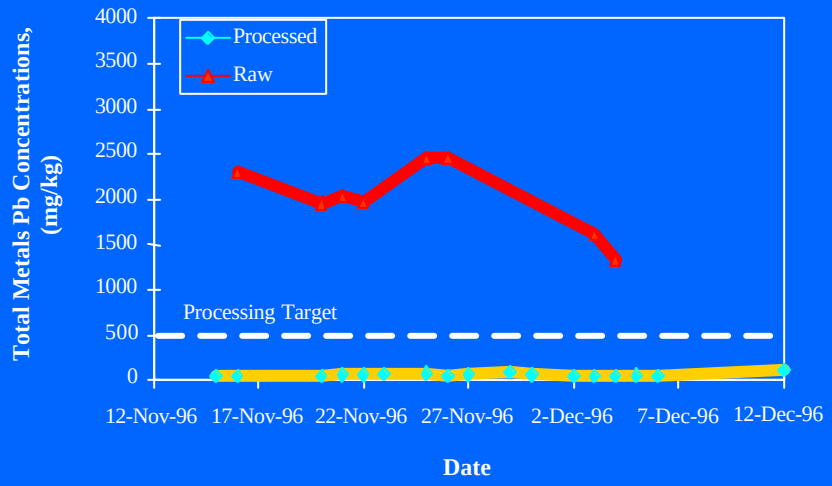
Vendor 2's Plant
- Physical Separation and HCl Leaching Process


Composite, v2*
*v2 ~300 lbs for ⅜" particles
Mixer
Dry
Sieve (⅜")
Sample Splitter
Remaining Sample
Roll Crusher
Sieve (10 Mesh)
Soil
(+10 Mesh)
Coarse
(+10 Mesh)
Fine (-10 Mesh)
Sort
1 Liter -⅜"
to Laboratory
for TCLP
Lead (+10 Mesh)
1 Liter -10 Mesh
to Laboratory
FTPOLK14.CDR

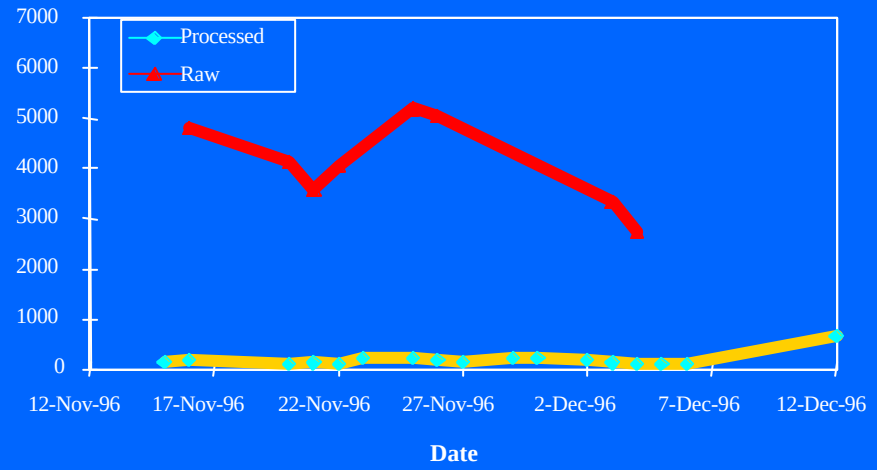

Sample Splitter
Remaining Sample
Roll Crusher
Sieve (10 Mesh)
Soil
(+10 Mesh)
Coarse
(+10 Mesh)
Fine (-10 Mesh)
Sort
1 Liter -⅜"
to Laboratory
for TCLP
Lead (+10 Mesh)
1 Liter -10 Mesh
to Laboratory
Field
FTPOLK14.CDR
Lab
Sample Splitter
Pyrometallurgical
Analysis
Ball Mill Grinder
100g
TCLP
100g
TCLP
20g
pH
+30 Mesh
Sort, Weigh
Screen (30 Mesh)
Ball Mill Grinder
Multiple 8g Digestions
to Analyze All Material
Screen (200 Mesh)
+200 Mes
Sample Splitter
8g
ICP
8g
ICP

Total Metals Removed During the Hydrochloric Acid Process

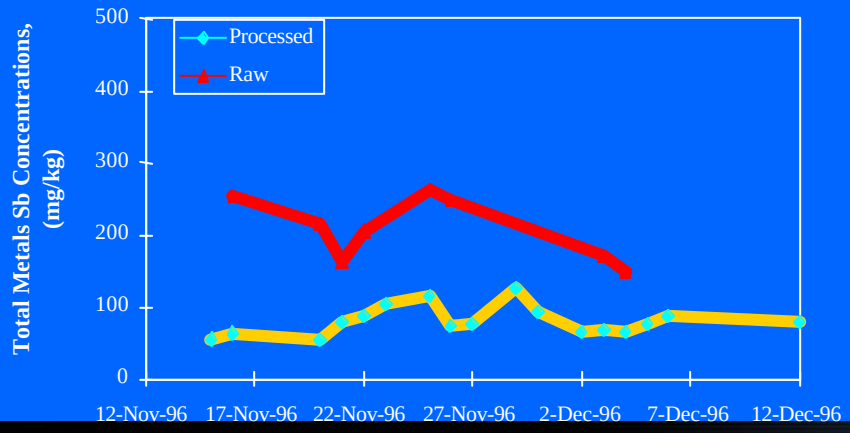
LEAD



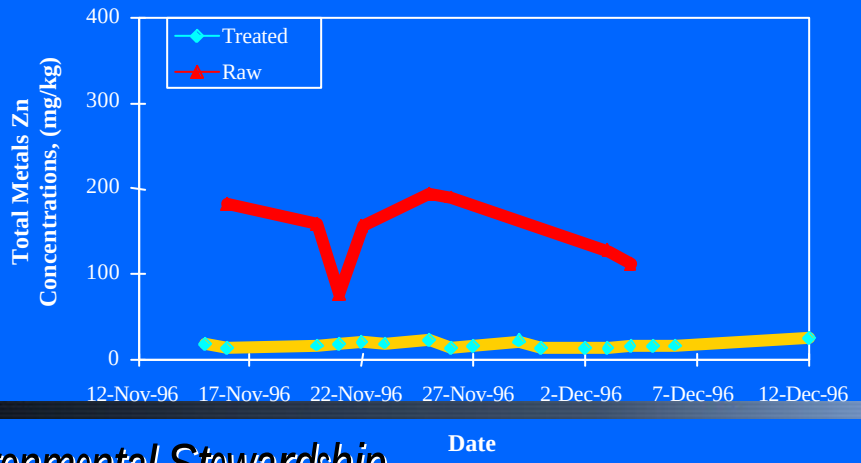
COPPER



ANTIMONY

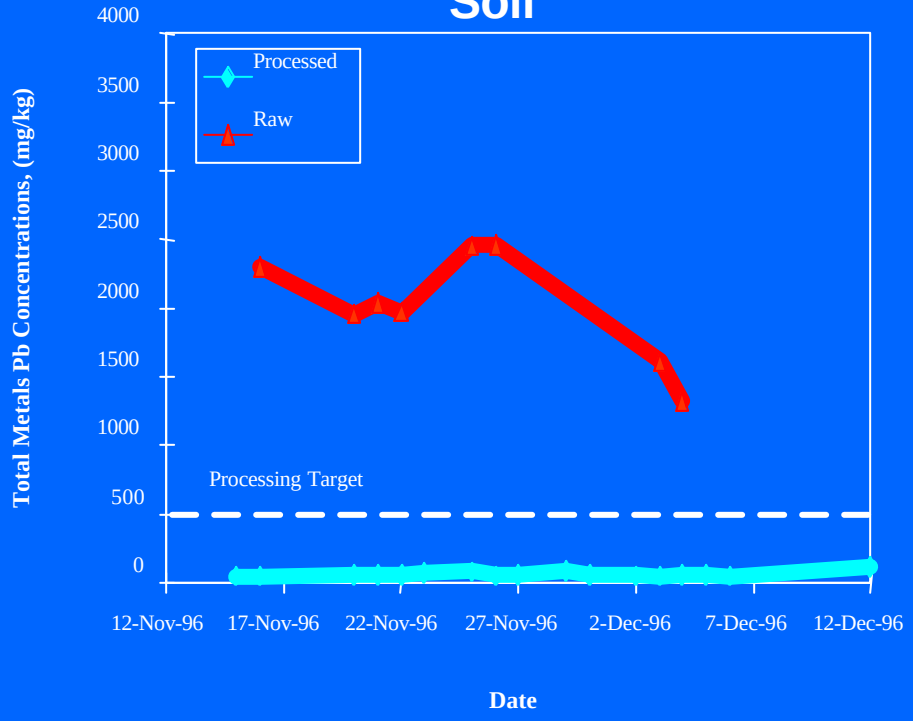


ZINC



Total and Leachable Lead Removal - HCL Process

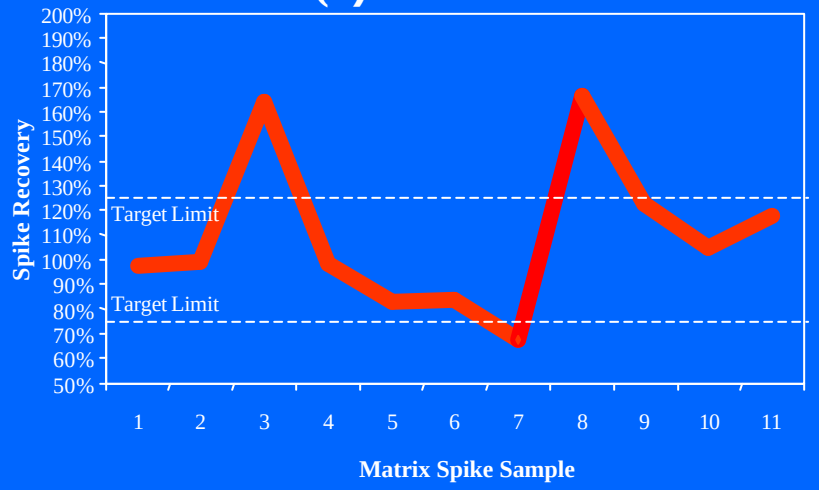
Total Pb Concentrations for Processed and Raw Soil



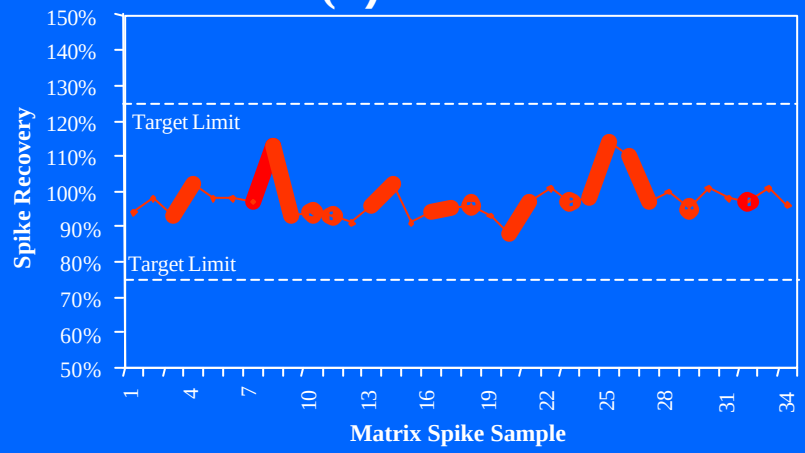
TCLP Pb Concentrations for Processed and Raw Soil

Accuracy Evaluation of Lead Analysis of Processed Soil

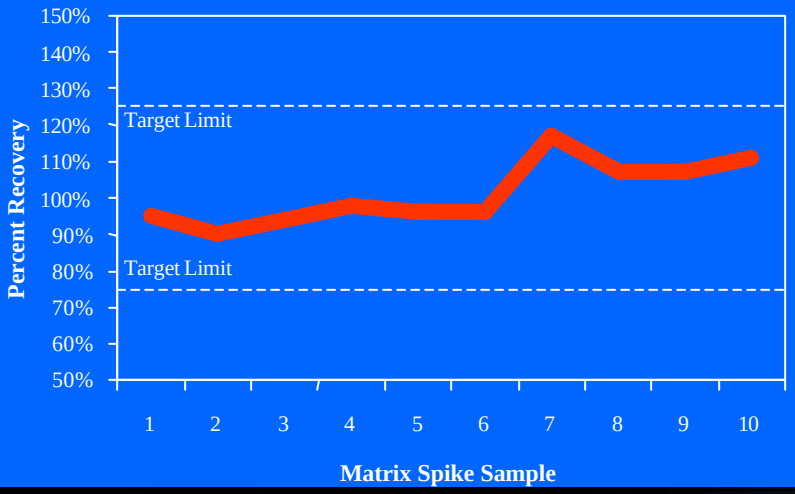
(a) Vendor 1 - Total Lead



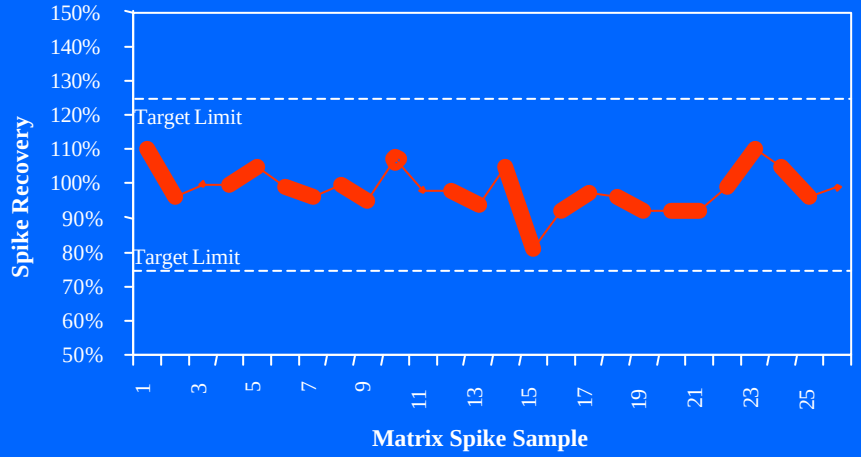
(b) Vendor 2 - Total Lead



(c) Vendor 1 - TCLP Lead

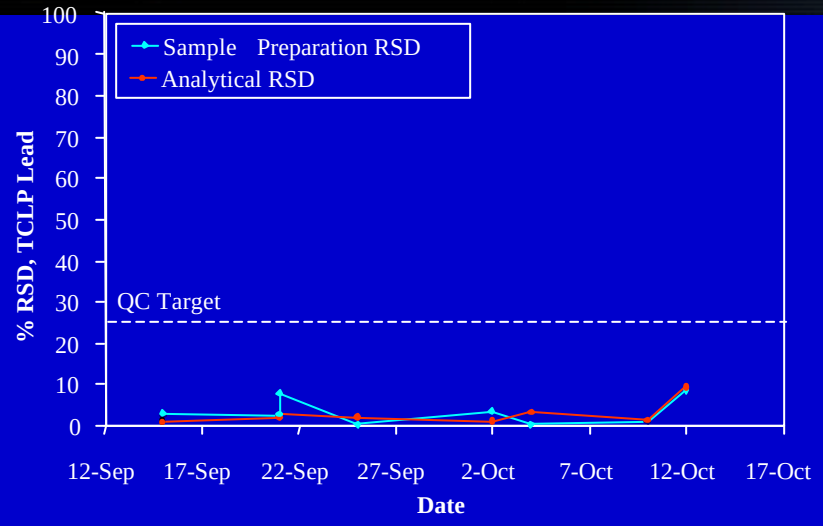


(d) Vendor 2 - TCLP Lead

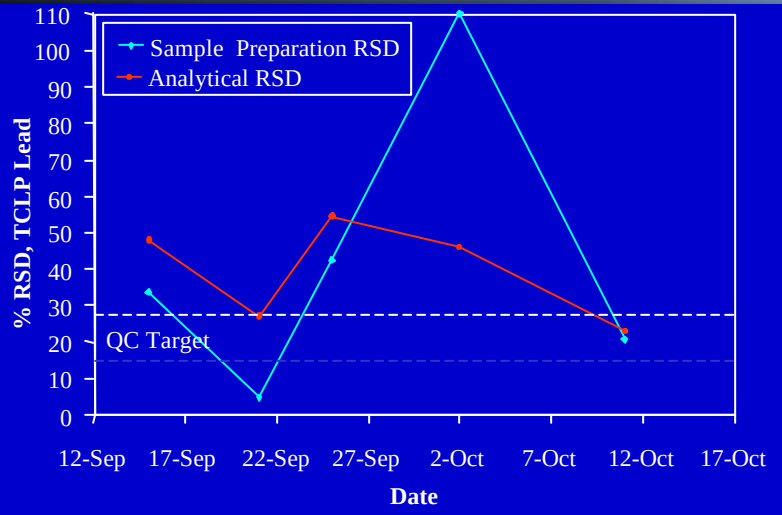


Precision Evaluation for TCLP Lead Analysis

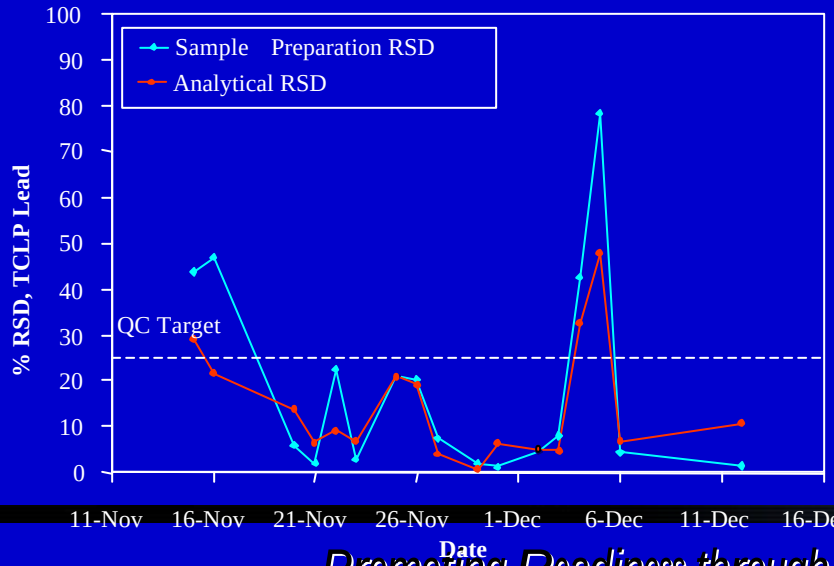
(a) Processed Soil - Vendor 1



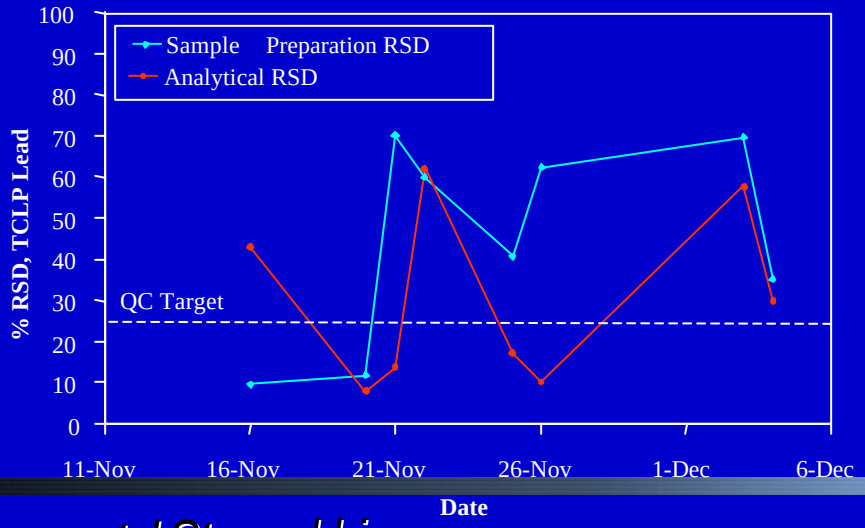
(b) Raw Soil - Vendor 1



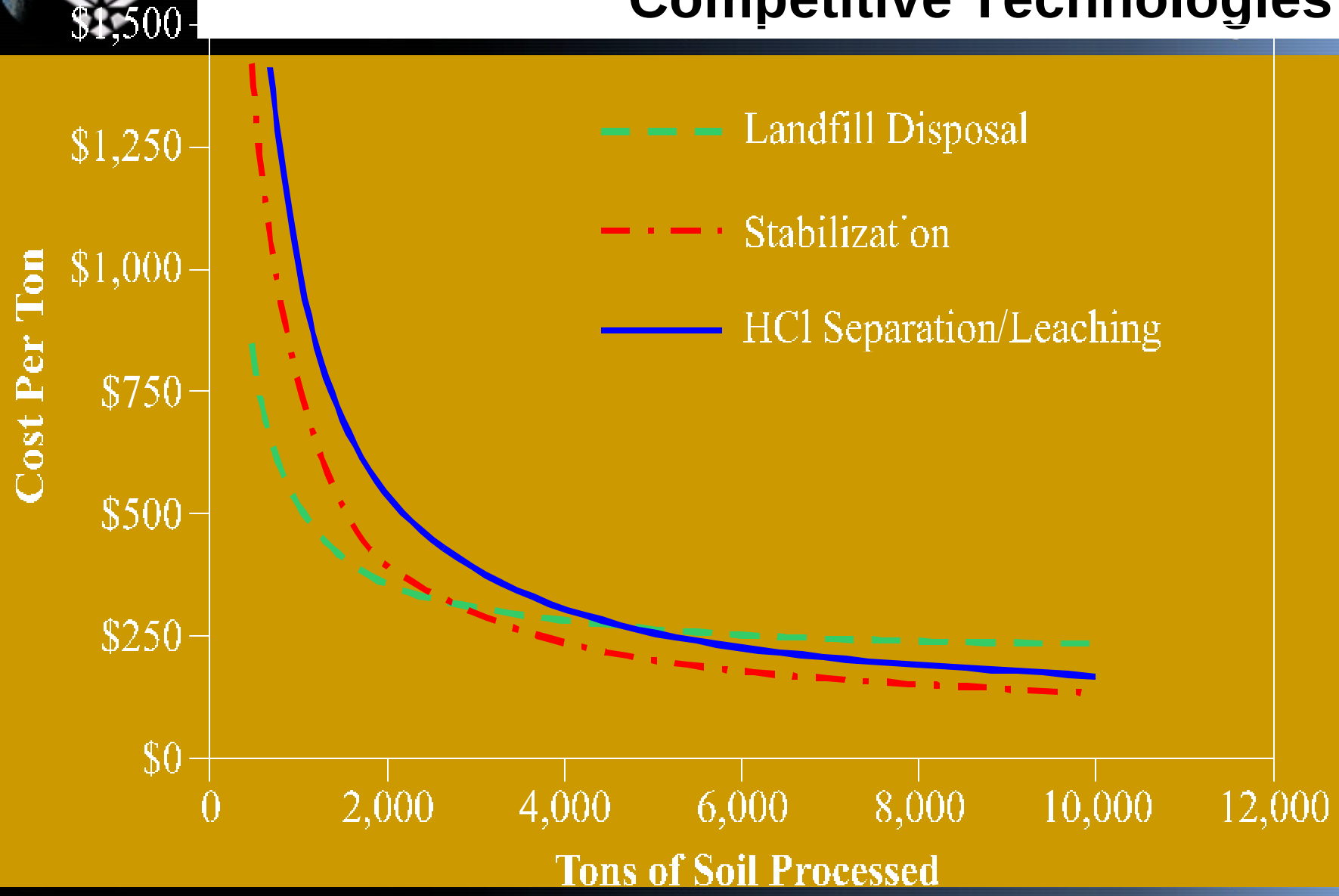
(c) Processed Soil - Vendor 2



(d) Raw Soil - Vendor 2



Fort Polk – Cost Comparison of Competitive Technologies



Small Arms Range Processing - Summary

- Marine Corps Base Camp Lejeune – Physical separation and phosphate stabilization at an active range

- Naval Air Station Mayport – Soil stabilization using cement

- No two sites are alike. Appropriate characterization and range processing method has to be determined on a site-specific basis, based on technical and cost factors

Small Arms Range Restoration at Marine Corps Base Camp Lejeune